GROUNDWATER QUALITY ASSESSMENT
AND ABATEMENT PROGRAM

FOR

[redacted]
MANHEIM, PENNSYLVANIA 17545

JANUARY 1984

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1.0 EXECUTIVE SUMMARY

1.1 BACKGROUND

Raymark Industries Inc. (Raymark) operates a dryclutch and special products manufacturing plant in Manheim, Pennsylvania. As part of its waste management system, Raymark operates a landfill. In response to a request from the Pennsylvania Department of Environmental Resources (PADER) Bureau of Solid Waste Management and in accordance with Pennsylvania Solid and Hazardous Waste Management regulations 75.265(n)(15), a groundwater quality assessment and abatement program for the landfill and its environs was prepared by BCM Eastern Inc. (BCM). The program was submitted to the PADER BY Raymark on August 2, 1983.

The groundwater quality assessment and abatement program was reviewed by the Bureau of Solid Waste Management and conditionally approved on September 22, 1983. PADER comments regarding the assessment and abatement program were listed in a letter from Robert G. Benvin, Facilities Supervisor, Harrisburg Regional Office, PADER Bureau of Solid Waste Management, to Mr. David M. Gioiello, Jr., Director, Health Safety and Environment, Raymark. A copy of this letter is included in Appendix 1. These comments are addressed within this report.

BCM was retained by Raymark to implement the assessment and abatement program. The program was implemented in October 1983 and completed in January 1984.

1.2 FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

1.2.1 Findings

1. Groundwater beneath the Raymark site occurs in two hydrogeologic regimes - alluvial deposits along Chickies Creek and the underlying carbonate bedrock. These two regimes are under water table conditions and are hydrogeologically connected.

2. Three high-yield wells are used for industrial water supply for the plant. These wells are developed along a linear region of weathered, possibly brecciated bedrock which may represent a fracture zone, fault, or joint in the carbonate bedrock.

ANY GW SOUNDINGS IN PLANT WELLS ???

3. Groundwater flow direction beneath the landfill is to the south-southwest. Pumping of the plant supply wells has lowered the water table in the vicinity of the landfill and induced groundwater flow towards the pumping wells.

4. As an apparent result of groundwater pumping, Chickies Creek in the vicinity of the landfill is an effluent stream discharging water to the local groundwater system.

5. Groundwater flow rate (velocity?) within the alluvium adjacent to Chickies Creek ranges from 18 to 37 feet per year.

RATE SHOULD BE IN L^3T^{-1}

6. Groundwater flow rate within the shallow weathered bedrock beneath the site ranges from 110 to 146 feet per year.

EPLER FORMATION OR STONEHENGE FORMATION

7. Groundwater flow rate within the fractured carbonate bedrock beneath the site is dependent on the size and frequency of bedrock fractures as well as the degree of solution activity which may have affected the soluble bedrock. In addition, water table lowering associated with plant supply well pumping affects flow velocity and induces flow towards the pumping wells.

P. 3-3 3000' NE SE

8. Based on available data, there are no private water supply wells in close proximity to the Raymark site. The closest public water supply well is 6,000 feet southwest of the landfill on the opposite side of two stream channels. It is extremely unlikely that the landfill would affect this supply well.

9. Hazardous waste or waste constituents were not detected at significant levels in the groundwater or surface water at the site.

10. Downgradient monitoring wells at the landfill show elevated levels of sulfate (a groundwater quality parameter) and bicarbonate. These constituents are the principal anions comprising the elevated levels of dissolved solids in these wells.

11. Data indicates that the plant's water supply wells have not been significantly affected by the constituents found in the monitoring wells.

12. Leachate generated in the laboratory from ~~landfill~~ samples generally exhibited low pH, high levels of sulfate, and low concentrations of lead ~~(<2~~ mg/l).

13. The underlying carbonate bedrock neutralizes acidic leachate from the landfill. This precipitates lead present and solubilizes carbonate in the form of bicarbonate.

14. Water quality data from Chickies Creek show no measurable impact from the landfill.

1.2.2 Conclusions

1. Available data indicate that no offsite private or public drinking water supply is affected by the Raymark landfill.

2. Groundwater quality within the immediate vicinity of the landfill contains elevated levels of sulfate and bicarbonate. Therefore, the development of drinking water supplies within the Raymark property would require careful well placement and testing.

3. The operation of the Raymark plant supply wells appears to contain potential migration of groundwater with elevated sulfates and bicarbonate within the plant site.

4. Should the Raymark plant supply wells be shut down in the future, the effect on Chickies Creek would be a minimal increase in sulfate concentration in the stream water from the current level of 20 mg/l to 50 mg/l.

5. The Raymark landfill represents the most probable source of elevated sulfate concentrations detected in shallow monitoring wells immediately adjacent to the landfill. The coal pile and storm sewer are not contributing to elevated levels of sulfates in the groundwater.

1.2.3 Recommendations

1. Continue to sample the monitoring wells and plant supply wells to identify any future changes in groundwater quality.

2. Establish Well 9 as the upgradient monitoring well for the landfill.

3. Continue to provide good management of solid waste to prevent spills on the ground surface from entering the storm sewer.

2.0 INTRODUCTION

2.1 SITE DESCRIPTION

The Raymark plant is located within Manheim Borough and Penn Township in Lancaster County, Pennsylvania. The Chickies Creek flows from north to south through the site forming the western boundary of the Raymark plant (see Figure 1). The landfill which is the subject of this groundwater assessment program is located north of the manufacturing buildings and east of Chickies Creek (see Figure 2).

The disposal area is used for the disposal of off-specification products and sludge from dust collectors associated with the manufacture of friction materials such as automobile clutch plates, brake shoes, and related products. Dust collector sludge is transported to the landfill in dumpster containers.

The older portions of the existing landfill are approximately 45 to 50 years old. Disposal operations began at the southwest and have proceeded towards the northeast property boundary.

The majority of the surface area of the older portions of the existing landfill is covered with relatively impermeable asphalt paving. The asphalt paving consists of an 8-inch crushed stone base course, a 1.5-inch asphalt filler, and a 1-inch asphalt binder course.

Currently, disposal operations are occurring northeast of the older portions of the landfill within an area designated as fill area 1. Future disposal operations are planned for areas designated as future fill areas 2 and 3 (see Figure 2). The future fill areas are surrounded by an earthen dike approximately 10 feet higher than land surface. Future fill areas will be covered with an asphalt cover similar to the older portions of the landfill when they are completed.

Approximately 6 inches of topsoil is used as final cover on the banks which make up the northern or southeastern perimeter of the older portions of the landfill. The soil has been seeded with crown vetch to prevent erosion. A similar soil and vegetation cover will be used on the perimeters of the future fill areas.

2.2 REGULATORY HISTORY

Raymark filed for interim status for the landfill because waste deposited in the facility contains lead. Solid waste that contains lead and exhibits the characteristic of EP toxicity and is not specifically listed

BCM Engineers, Planners and Scientists

RAYMARK INDUSTRIES, Inc.
Manheim, PA

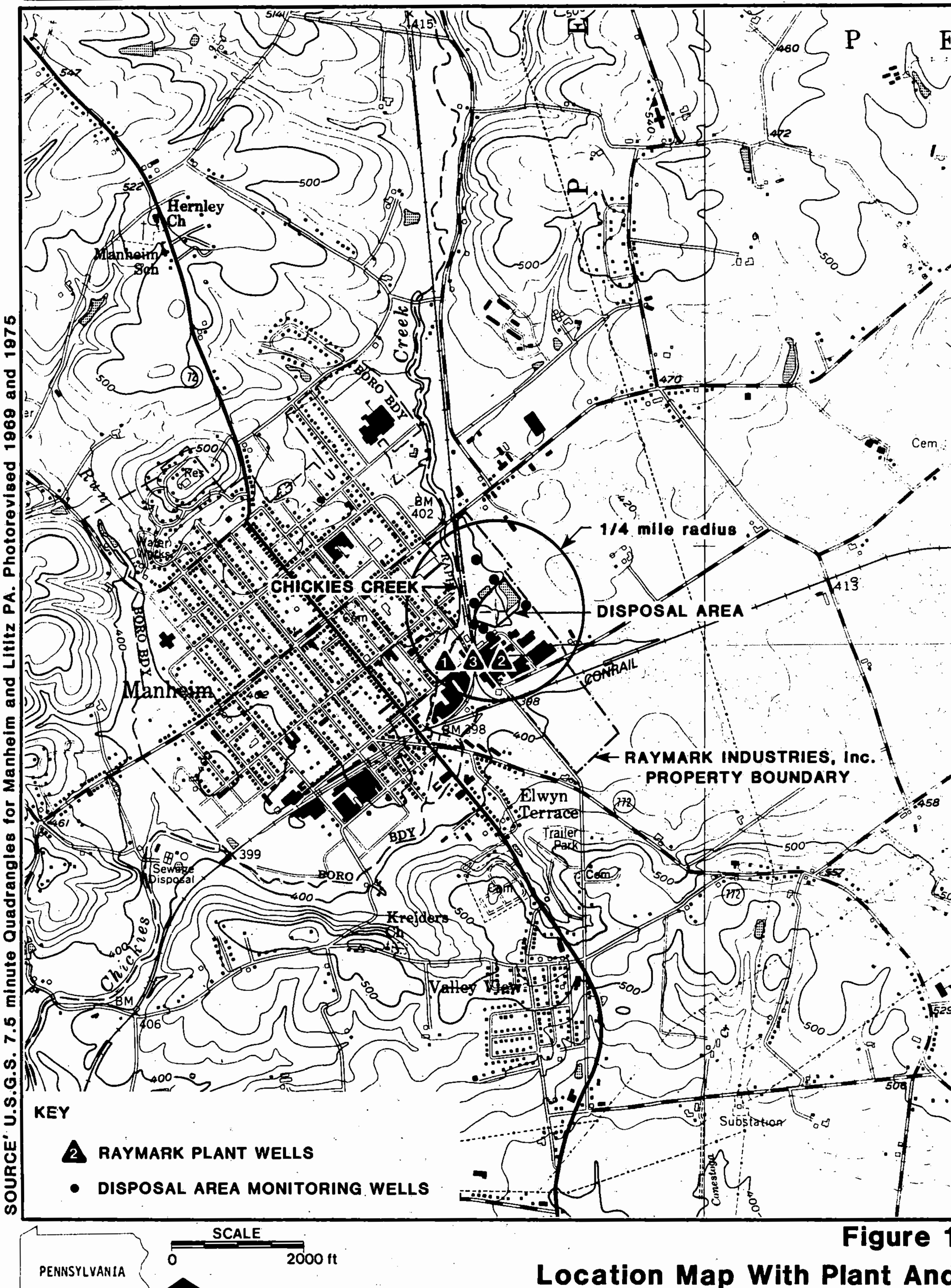
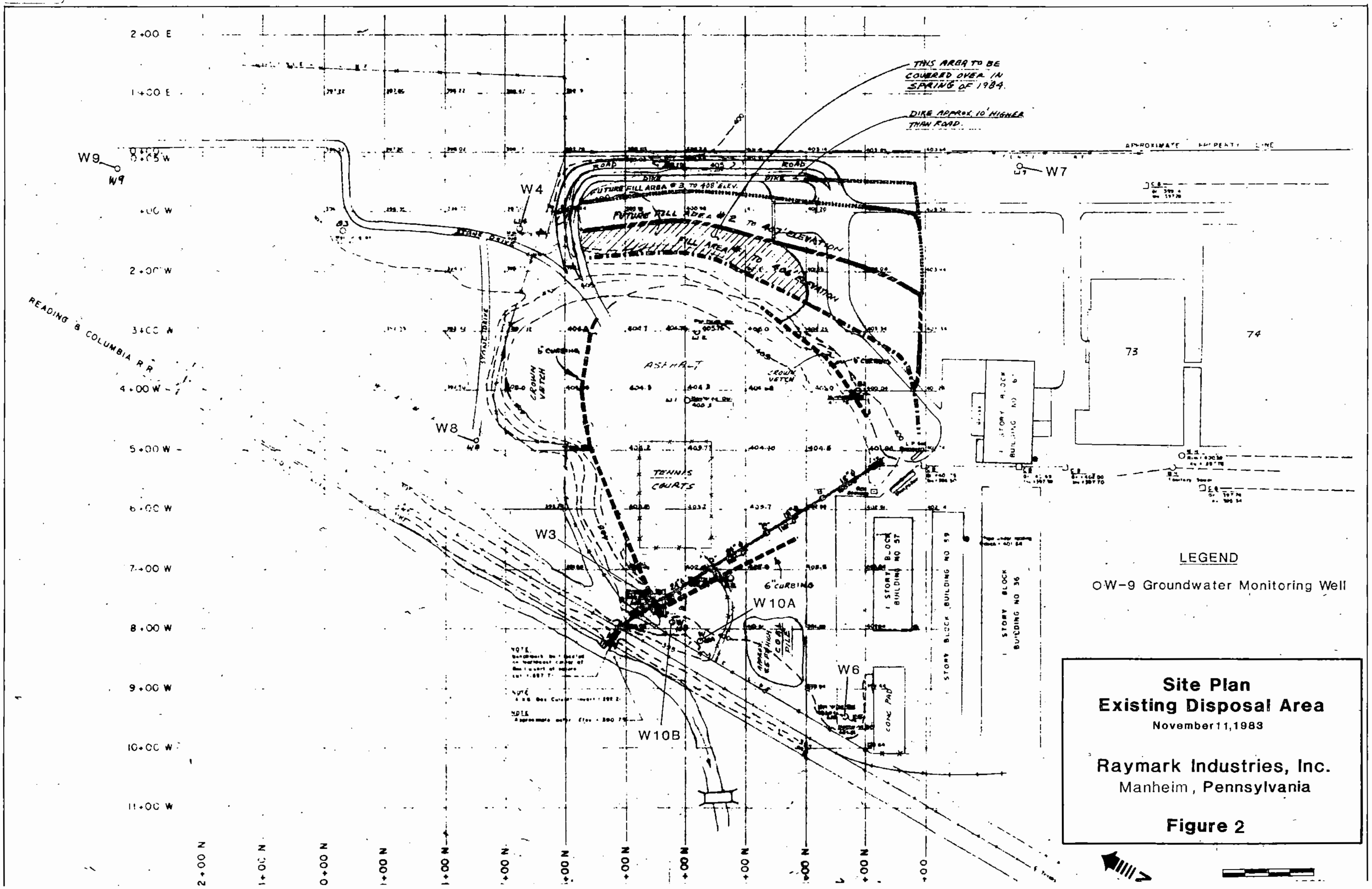


Figure 1

Location Map With Plant And Monitoring Well Locations

BCM Eastern inc.



Site Plan
Existing Disposal Area
November 11, 1983

Raymark Industries, Inc.
Manheim, Pennsylvania

Figure 2

Source: Raymark Drawing D17370, Disposed Area Existing, November 11, 1983.

as a hazardous waste has the EPA hazardous waste number D008. The wastes are retained for more than 90 days; therefore, the landfill is a storage facility.

The facility has the PADER designation PA 003015328.

As required by the Pennsylvania Hazardous Waste Management Regulations 75.265 (n) (1-13), a groundwater monitoring program was initiated for the landfill in November 1981.

Quarterly sampling was completed on November 18, 1981, February 24, 1982, September 9, 1982 and November 17, 1982. The second year of the program included quarterly sampling on March 9, 1983, August 4, 1983, September 29, 1983, and November 7, 1983. Analytical results and water level data were submitted to the PADER following the completion of each quarterly analysis.

A comparison of upgradient and downgradient parameters used to indicate the presence of groundwater contamination was completed following analysis of the second year, first quarter (March 9, 1983) sampling and analysis. This comparison was conducted in accordance with Pennsylvania Solid and Hazardous Waste Management Regulations 75.265(n)(14) and Appendix III and indicated statistically significant changes in pH, specific conductance, and total dissolved solids in the downgradient monitoring wells. In addition, elevated concentrations of sulfate (a groundwater quality parameter) were noted in downgradient wells 3 and 6.

The groundwater assessment and abatement program was prepared following review of the second year, first quarter analytical data. The assessment and abatement program was designed to accomplish the following goals:

1. Determine which hazardous waste or hazardous waste constituents (if any) have entered the groundwater.

2. Determine the rate and extent of migration of hazardous waste or hazardous waste constituents (if present) in the groundwater.

3. Determine the concentrations of hazardous waste or hazardous constituents (if any) in the groundwater.

4. Abate any groundwater contamination (if present) attributable to the hazardous waste management facility.

5. Better define the groundwater system.

3.0 SITE GEOLOGY AND HYDROGEOLOGY

3.1 GEOLOGY

The Raymark plant site is located within the Piedmont physiographic province. Bedrock of the Piedmont Province consists mainly of pre-Cambrian crystalline rocks, Ordovician carbonate rocks, and Triassic sandstone, shale, and diabase.

The Raymark plant site and surrounding area is underlain by carbonate bedrock. Bedrock in the vicinity of Manheim and the Raymark plant is extensively folded and faulted. The plant site is located within an east-west trending carbonate valley surrounded by shale bedrock which forms highlands north, south, and west of Manheim Borough.

Raymark is believed to be located on the crest of the Manheim anticline, which is a large overturned fold that strikes east and plunges west. The upper limit of the anticline is exposed just south of Manheim Borough.

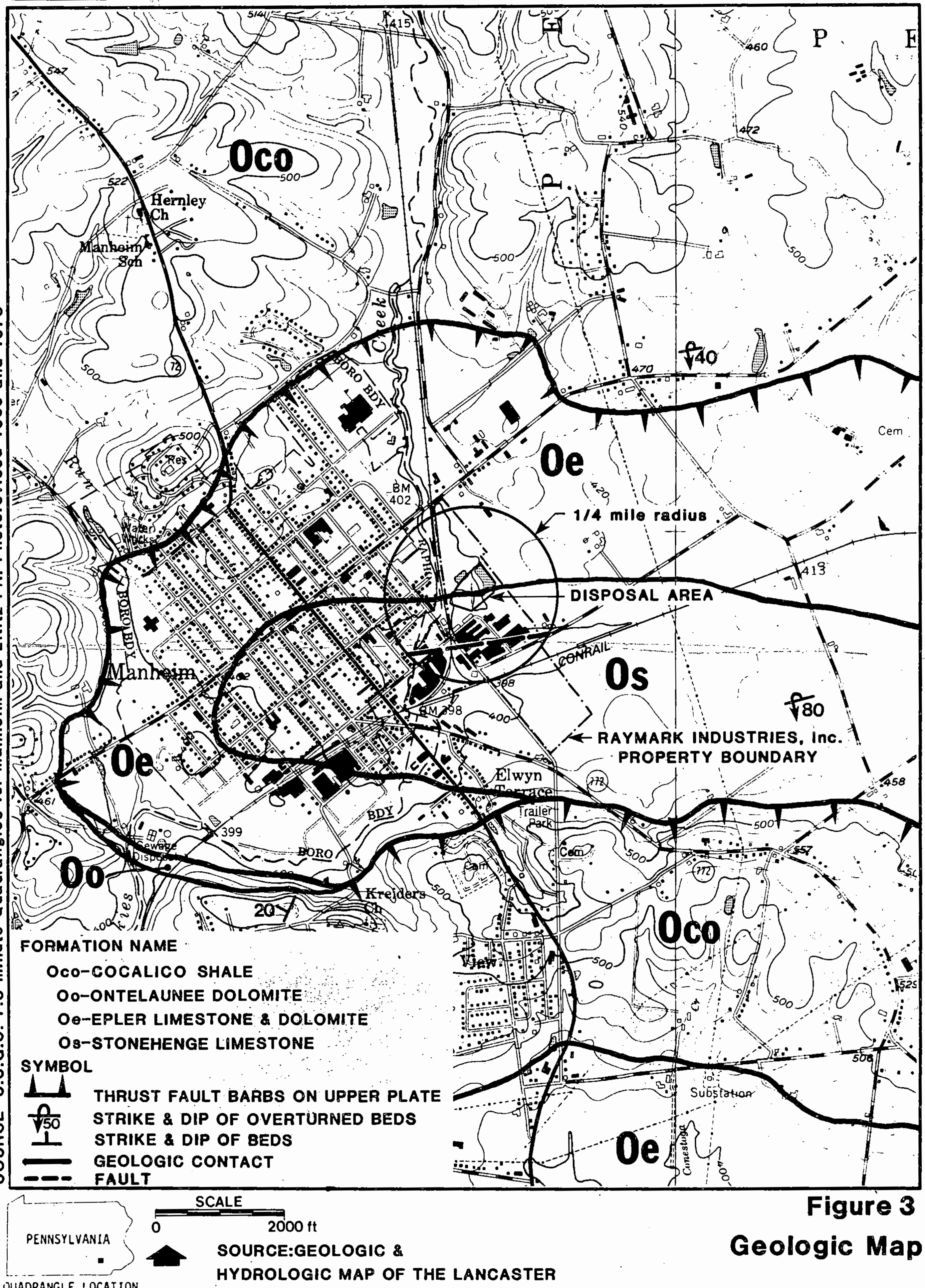
On-site examination indicates that the Raymark plant site is underlain by two geologic formations of the Beekmantown Group: the Stonehenge limestone and the Epler limestone and dolomite. The contact between these two formations trends east-west and passes underneath the existing disposal area (see Figure 3).

The Stonehenge Formation ranges in thickness from 500 to 1,000 feet. It is characteristically a gray, finely crystalline limestone with dark shaley laminae.

The Epler Formation is estimated to be between 2,000 and 2,500 feet thick. It is an interbedded limestone and dolomite which overlies the Stonehenge Formation. The Epler is predominantly a dolomite with gradations between pure dolomite and pure limestone present.

Depth to bedrock, identified in Raymark's plant water supply and disposal area monitoring wells, ranges from 6 to 25 feet below land surface.

A fault has been identified within the Stonehenge limestone east of the Raymark plant site. This fault was reported by Stose and Jonas in the Atlas of Pennsylvania Geology, No. 168, Lancaster County, 1930. The fault has been projected onto the Raymark plant site approximately 500 feet south of the disposal area by previous investigators exploring for groundwater supply for Raymark (see Figure 3). Although several plant water supply wells located along this fault have encountered weathered and brecciated bedrock and solution cavities yielding large volumes of water, this "fault" may just as likely represent a fracture zone or joint, which would have similar characteristics.



SOURCE: U.S.G.S. 7.5 minute Quadrangles for Manheim and Lititz PA. Photorevised 1969 and 1975

SOURCE: GEOLOGIC & HYDROLOGIC MAP OF THE LANCASTER 15-MIN. QUAD. MEISLER & BECHER, 1970

Figure 3

Geologic Map

3.2 HYDROGEOLOGY

3.2.1 Site Hydrogeology

Groundwater in the vicinity of the Raymark landfill occurs in two hydrogeologic regimes. Groundwater is contained within the alluvial deposits along the Chickies Creek floodplain and within the underlying carbonate bedrock. An analysis of water level measurements taken in landfill monitoring wells indicates that the two regimes are hydrogeologically connected.

Groundwater contained within the alluvial deposits occurs under water table conditions. Groundwater within the carbonate bedrock is contained within crevices and solution openings. Water contained within these openings also is under water table conditions. However, water within these zones may be under pressure, and the water in a well penetrating these water-bearing zones will rise above the level of the opening.

The two carbonate rock formations which underlie the Raymark landfill differ in their capability to store and transmit water. The Stonehenge Formation, underlying the southern portion of the landfill, has the higher yields of the two formations. The mean specific capacity (rate of yield of a well in gallons per minute (gpm) expressed as the rate of yield per unit of drawdown (gpm/ft)) of 17 wells tapping the Stonehenge Formation is 121 gpm/ft. The Epler Formation, which underlies the northern portion of the landfill, is much less productive aquifer, yielding a mean of only 21 gpm/ft for 50 wells.

3.2.2 Water Supply Inventory

A review of available PADER well records for the area in which the Raymark landfill is located indicated that the closest private water supply wells are approximately 3,000 feet northeast and 3,000 feet southeast of the landfill.

Raymark operates three industrial process and cooling water supply wells located approximately 500 feet south of the landfill. These wells are designated Plant Well 1, Plant Well 2, and Plant Well 3. Wells 1, 2, and 3 are 300, 312, and 42 feet deep, respectively. The wells are equipped with vertical turbine pumps. Wells 1 and 2 are connected to hydropneumatic tanks with automatic on-off controls and are pumped intermittently at 200 and 390 gallons per minute (gpm), respectively. Well 3 is pumped at 400 gpm. Pumpage from Well 3 is controlled automatically by line pressure in the plant water system.

The total amount of water used daily varies with production rates. The wells are capable of producing 990 gpm if that amount of water is necessary. Water from these plant wells is used for industrial and sewage purposes only. Drinking water within the plant buildings is supplied by the Manheim Borough water system.

Manheim Borough has recently developed a water supply well near the confluence of Chickies Creek and Rife Run approximately 6,000 feet southwest of the Raymark facility. The well is near an existing quarry used as a reservoir for Borough water supply and is on the opposite (west) side of Chickies Creek and Rife Run from the landfill.

3.2.3 Groundwater Flow Direction and Rate

As a portion of the groundwater assessment program, water level measurements were taken in monitoring wells at the Raymark plant site on October 13 and November 7, 1983. The data from November 7 were used to construct a groundwater contour map (see Figure 4). Water table elevations are listed in Table 3-1.

Data from Wells 3, 4, 7, 8, 9, 10A, and 10B were used to construct the groundwater contour map. Data from Well 6 indicated a water table elevation higher than nearby wells (10A, 10B, W3), indicating that Well 6 penetrated a water-bearing zone under greater pressure than the nearby wells.

An analysis of the groundwater contour map indicates a groundwater flow direction to the south-southwest. Groundwater was encountered in these wells at depths ranging from 4.7 to 16.5 feet below land surface.

An analysis of creek and water table elevations in the reach of Chickies Creek adjacent to the Raymark landfill indicates that the water table as measured in the landfill monitoring wells is below the lowest point in the stream bed. Therefore, the stream, if hydrogeologically connected to the adjacent aquifer, will discharge water to the groundwater system. This localized discharge of creek water to the groundwater system is the opposite of the normal process of groundwater flow adjacent to Chickies Creek. Normally groundwater discharges to creeks through seeps and springs along the length of the creek. Base flow of perennial streams such as Chickies Creek is normally maintained by this groundwater discharge. Apparently, pumping of the plant supply wells has lowered the water table in the vicinity of the landfill and induced groundwater flow towards the pumping wells. The south-southwest groundwater flow direction beneath the landfill may be a response to plant pumping.

3.2.4 Groundwater Flow Rate

Permeability of the unconsolidated material encountered in Well 10A was measured via a bail test. The method used is described in A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifer With Completely or Partially Penetrating Wells (Bower and Rice 1976). A copy of this publication and bail test recovery data and permeability calculations are included in Appendix 2.

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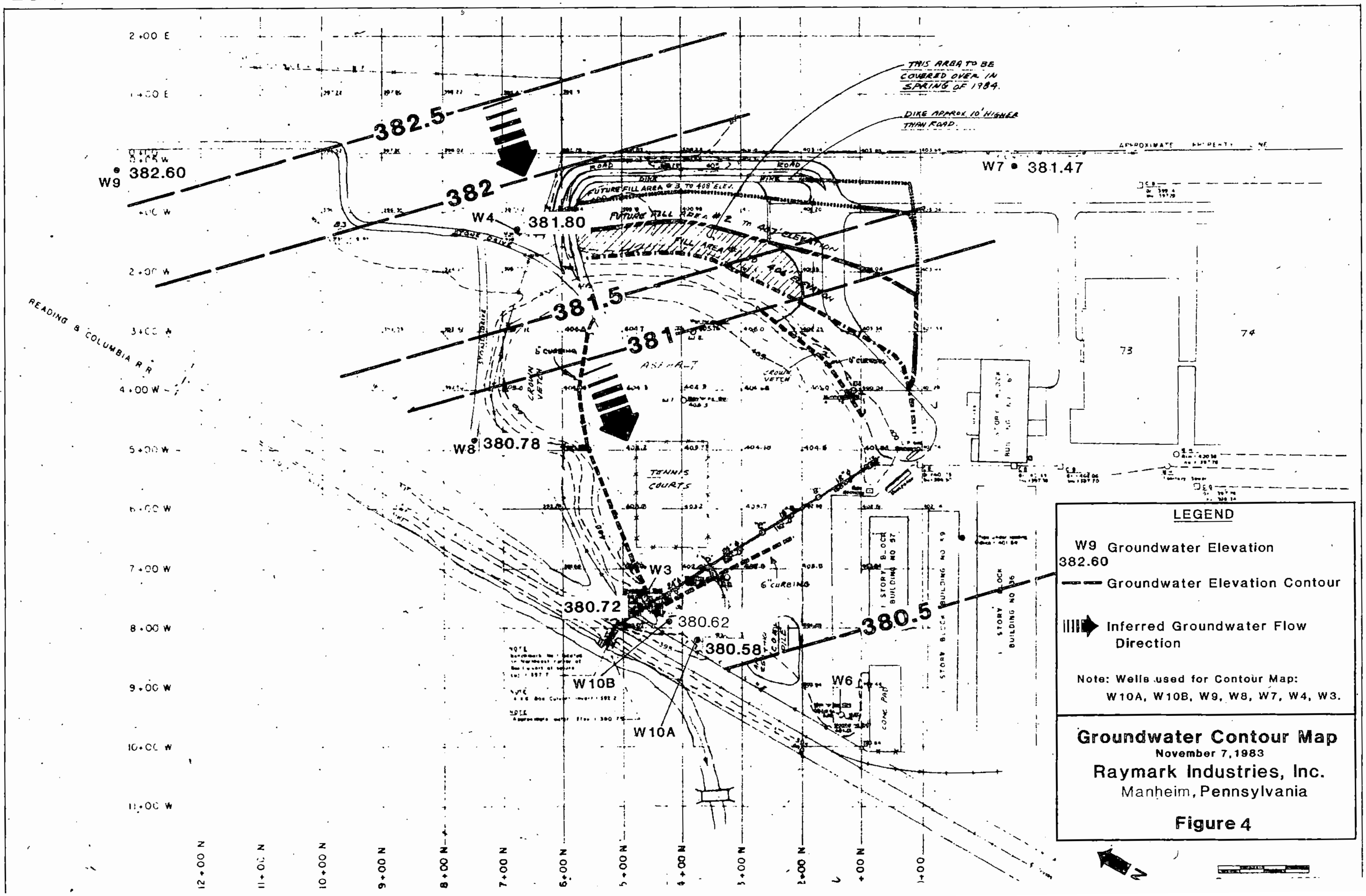

Groundwater Contour Map
November 7, 1983
Raymark Industries, Inc.
Manheim, Pennsylvania

Figure 4

Source: Raymark Drawing D17370, Disposed Area Existing, November 11, 1983.

TABLE 3-1

WATER TABLE ELEVATIONS
NOVEMBER 7, 1983

Well No.	Depth to Water (feet)	Water Table Elevation (feet above mean sea level)	Hydrogeologic Regime
3	9.75	380.72	Shallow Bedrock
4	6.00	381.80	Shallow Bedrock
6	16.04	386.76	Shallow Bedrock
7	16.50	381.47	Deep Bedrock
8	4.71	380.78	Alluvium
9	7.71	382.60	Alluvium
10A	8.27	380.58	Alluvium
10B	6.65	380.62	Deep Bedrock

Measured permeability of the unconsolidated material at Well 10A was 7 to 10 feet per day. Using a measured water table gradient of 0.002 foot/foot and an assumed porosity of 5 percent for the material encountered in Well 10A, calculation of the average velocity of groundwater flow near Well 10A indicates a flow rate ranging from 0.3 to 0.4 feet/day, or 110 to 146 feet/year. Calculations using an assumed porosity of 30 percent, which may be more accurate for the alluvial material encountered along Chickies Creek, indicates a flow rate ranging from 0.05 to 0.1 feet/day, or 18 to 37 feet/year.

These calculated flow rates provide an estimated rate of groundwater flow within the alluvium and shallow weathered bedrock at the site. Groundwater flow rates within the deeper bedrock at the site are difficult to estimate, due to the nature of fractured carbonate bedrock. Flow rates within this hydrogeologic regime will be dependent on the size and frequency of bedrock fractures, as well as on the degree of solution activity which may have affected the soluble bedrock. In addition, pumping of the plant supply wells will affect groundwater flow rates in the vicinity of these wells. It is likely that a cone of depression of the water table has been created by pumping. This water table lowering will affect flow velocity and induce flow towards the pumping wells.

3.2.5 Hydrogeologic Analysis - Nearby Wells

Not tested

As mentioned in Section 3.2.2, the closest public water supply well to the landfill is Manheim Borough's well located 6,000 feet southwest of the landfill. Raymarks's plant supply wells (located 500 feet south of the landfill) are used for process and cooling water only.

It is extremely unlikely that the landfill would affect the Borough supply well. The zone from which the Borough well draws water would not be expected to extend 6,000 feet to the landfill. In addition, the Borough well would probably cause induced infiltration from Chickies Creek and Rife Run; therefore the area of recharge to the well would remain relatively local to the well site.

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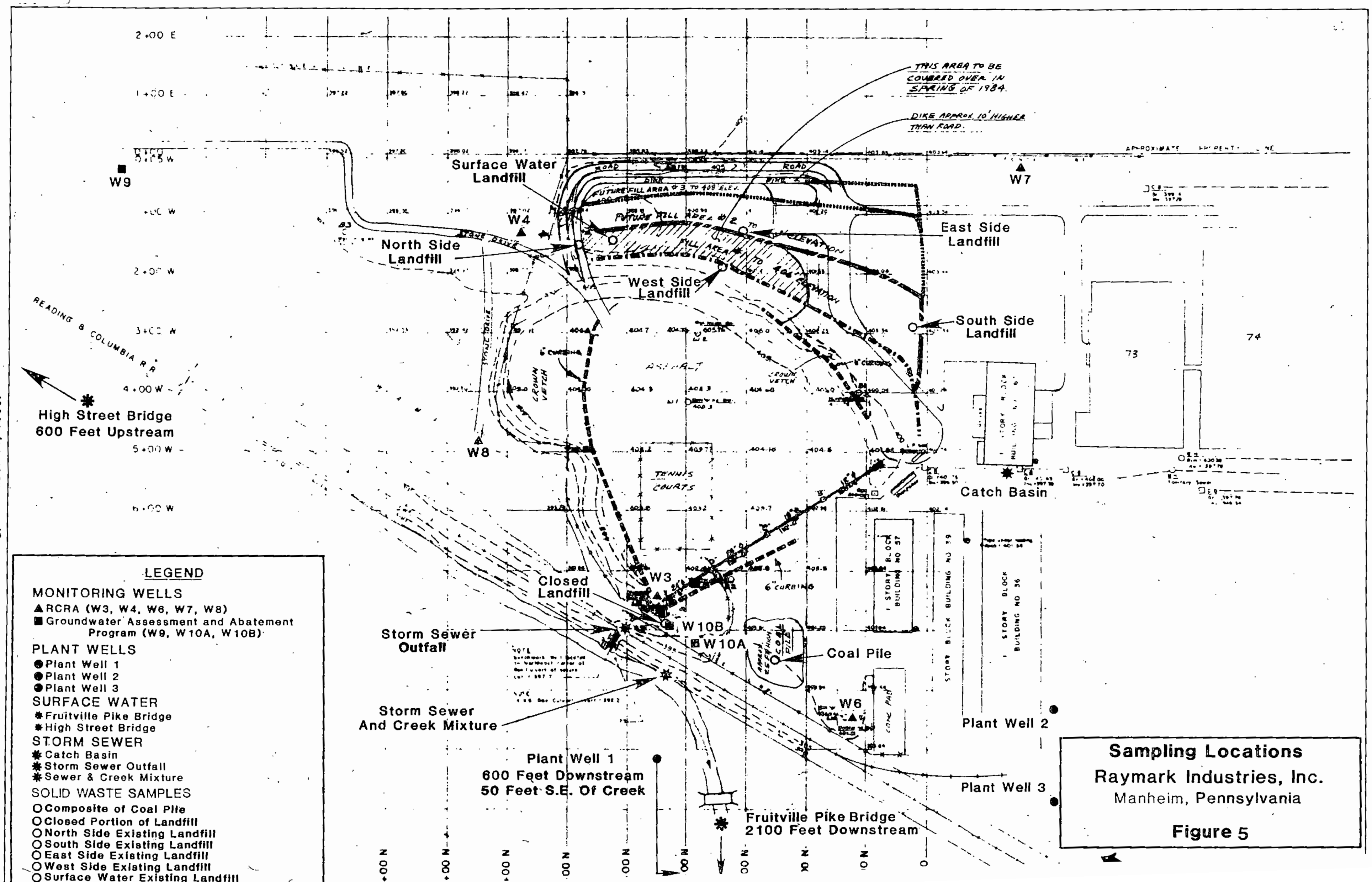

Sampling Locations
Raymark Industries, Inc.
Manheim, Pennsylvania

Figure 5

urce: Raymark Drawing D17370, Disposed Area Existing, November 11, 1983.

4.0 MONITORING WELL NETWORK

4.1 WELL DETAILS

Five monitoring wells (wells 3, 4, 6, 7, and 8), are currently sampled as part of the RCRA monitoring program for the Raymark landfill. RCRA groundwater monitoring regulations (40 CFR 265.91(a)) require that a minimum of one upgradient and three downgradient wells be utilized to monitor the uppermost aquifer at the limit of a waste management area. Monitoring well 7 has been selected at Raymark's landfill as the upgradient well, and wells 3, 4, 6, and 8 have been selected as the downgradient wells.

In addition to the RCRA monitoring wells, three monitoring wells were installed by BCM as a portion of this groundwater assessment and abatement program in October 1983. These wells are designated 9, 10A, and 10B.

Well logs for the RCRA monitoring wells (wells 3, 4, 6, 7, and 8) and the wells installed as a portion of this study (9, 10A, 10B) are contained in Appendix 3. Monitoring well details are summarized in Table 4-1.

Wells 3, 4, 6, 7, 8, and 10B each are equipped with a permanent submersible pump installed at the bottom of the well. Wells 9 and 10A are shallow wells and one not fitted with submersible pumps.

All wells are finished at the surface with a 36-inch square concrete pad, a locking cap, and steel bumper guards. The concrete pad is sloped to direct runoff away from the well head. The elevations of the top of casing of all wells was surveyed to within 0.01 foot; these elevations are included in Table 4-1.

4.2 QUARTERLY SAMPLING DATA

Quarterly sampling of the RCRA monitoring wells has been completed for a two year period. First year data are summarized in Tables 4-2 through 4-6. Second year first, second, and third quarter data are summarized in Tables 4-7, 4-8, and 4-9. Second year fourth quarter data was available in preliminary form only at the time of this report.

TABLE 4-1

MONITORING WELL DETAILS

Well No.	Completion Date	Elevation * (Top of Casing)	Total Depth (feet)	Total Cased (feet)	Screened Interval (feet)	Estimated Yield (gpm)	Hydrogeologic Regime
3	05/14/75	390.47	35	20.3	--	25 to 50	Shallow Bedrock
4	05/14/75	387.80	44	26	--	100	Shallow Bedrock
6	05/14/75	402.80	25	15	--	25	Shallow Bedrock
7	11/20/81	397.97	80	6	--	0.1	Deep Bedrock
8	11/19/81	385.49	25	14	13 to 18	25 to 50	Alluvium
9	10/07/83	390.31	17.5	5	3 to 17.5	20	Alluvium
10A	10/07/83	388.85	13.5	5.5	3.5 to 13.5	1	Alluvium
10B	10/06/83	387.27	77	19	--	3 to 5	Deep Bedrock

* All elevations reported with respect to mean sea level

TABLE 4-2

GROUNDWATER MONITORING DATA

WELL 3

Down

Parameter*	Date Sampled** 11/18/81	02/24/82	09/09/82	11/17/82
PARAMETERS TO INDICATE GROUNDWATER CONTAMINATION				
pH (units)***	7.4	7.2	7.2	7.19
Total Dissolved Solids***	4,520	2,772	4,636	2,376
Specific Conductance (umhos/cm)***	5,200	2,900	2,725	3,025
Total Organic Halogen***	0.037	0.028	1.200	0.216
Total Organic Carbon***	2.0	149	162.	34
OTHER PARAMETERS				
Arsenic	<0.001	<0.001	0.0044	0.0013
Barium	0.3	0.2	0.2	0.2
Cadmium	<0.01	<0.01	<0.005	<0.005
Chromium	0.05	0.01	0.006	0.01
Copper	N/A	0.02	0.03	0.01
Lead	<0.01	0.01	0.008	<0.005
Mercury	<0.001	<0.001	<0.0005	<0.005
Selenium	<0.001	<0.001	<0.001	<0.001
Silver	0.01	<0.01	0.02	0.01
Zinc	N/A	0.48	0.24	0.15
Fluoride	1.64	1.4	2.4	1.31
Nitrites	0.006	0.14	N/A	N/A
Nitrates	0.227	0.169	0.041	0.015
Radium 226 (pCi/l)	<3.0	<3.0	0.4	0.2
Gross Alpha (pCi/l)	0.8	3.9	0	0.2
Gross Beta (pCi/l)	16	28	38	16.4
Turbidity (NTU)	74	36	80	65
Total Coliform (#/ml)	<2.0	<1.0	<1.0	<1.0
Endrin (ug/l)	<0.02	<0.02	<0.01	<0.01
Lindane (ug/l)	<0.01	<0.02	<0.01	<0.01
Methoxychlor (ug/l)	<0.1	<0.1	<0.01	<0.01
2,4-D (ug/l)	<1.0	<1.0	<1.0	<1.0
2,4,5-TP Silvex (ug/l)	<1.0	<1.0	<1.0	<1.0
Toxaphene (ug/l)	<1.0	<1.0	<0.5	<0.5
Chlorides	85	47	115	34
Sodium	320	173	452	158
Phenols	<0.005	0.013	0.016	0.015
Maganese	3.3	2.5	5.0	2.36
Iron	0.35	3.7	10.1	7.0
Sulfates	1,900	1,060	1,930	871

* All values in milligrams/liter (mg/l) unless otherwise specified.
** Collection and analysis performed by Chester Engineers
*** Quadruplicate analysis
N/A = Not analyzed

TABLE 4-3

GROUNDWATER MONITORING DATA

WELL 4

Down

Parameter*	Date Sampled** 11/18/81	02/24/82	09/09/82	11/17/82
PARAMETERS TO INDICATE GROUNDWATER CONTAMINATION				
pH (units)***	7.8	7.0	7.0	7.08
Total Dissolved Solids***	348	808	744	636
Specific Conductance (umhos/cm)***	650	930	1,100	980
Total Organic Halogen***	6.010	0.020	0.172	0.021
Total Organic Carbon***	2.0	58	97	<1.0
OTHER PARAMETERS				
Arsenic	<0.001	<0.001	<0.001	<0.001
Barium	0.1	0.1	0.1	0.1
Cadmium	<0.01	<0.01	<0.005	<0.005
Chromium	<0.01	<0.01	<0.005	<0.01
Copper	N/A	0.02	0.01	0.01
Lead	0.01	<0.01	<0.005	<0.005
Mercury	<0.001	<0.001	<0.0005	<0.0005
Selenium	<0.001	<0.001	<0.001	<0.001
Silver	<0.01	<0.01	<0.01	<0.01
Zinc	N/A	0.08	0.14	0.08
Fluoride	0.04	0.32	0.46	0.26
Nitrites	0.002	<0.01	N/A	N/A
Nitrates	4.9	0.87	0.6	6.86
Radium 226 (pCi/l)	<3.0	<3.0	0.1	0.1
Gross Alpha (pCi/l)	2.7	<0.5	1.2	0.0
Gross Beta (pCi/l)	<7.3	<1.0	1.0	23.3
Turbidity (NTU)	2.2	1.6	4.0	12
Total Coliform (#/ml)	8.0	<1.0	<1.0	<1.0
Endrin (ug/l)	<0.02	<0.02	<0.01	<0.01
Lindane (ug/l)	<0.01	<0.02	<0.01	<0.01
Methoxychlor (ug/l)	<0.1	<0.1	<0.1	<0.1
2,4-D (ug/l)	<1.0	<1.0	<1.0	<1.0
2,4,5-TP Silvex (ug/l)	<1.0	<1.0	<1.0	<1.0
Toxaphene (ug/l)	<1.0	<1.0	<0.5	<0.5
Chlorides	20	19	22	24
Sodium	12	41	43	28
Phenols	<0.005	0.10	0.011	0.009
Maganese	0.01	0.55	0.36	0.05
Iron	0.72	0.65	0.64	0.70
Sulfates	46	207	157	142

* All values in milligrams/liter (mg/l) unless otherwise specified.
** Collection and analysis performed by Chester Engineers
*** Quadruplicate analysis
N/A = Not analyzed

Betz • Converse • Murdoch • Inc.

TABLE 4-4

GROUNDWATER MONITORING DATA
WELL 6

Down

Parameter*	Date Sampled** 11/18/81	02/24/82	09/09/82	11/17/82
PARAMETERS TO INDICATE GROUNDWATER CONTAMINATION				
pH (units)***	7.1	7.1	7.0	7.0
Total Dissolved Solids***	1,998	1,880	2,296	2,068
Specific Conductance (umhos/cm)***	2,200	1,900	2,250	2,300
Total Organic Halogen***	0.028	0.018	0.091	0.063
Total Organic Carbon***	<0.5	32	37	2.0
OTHER PARAMETERS				
Arsenic	<0.001	<0.001	<0.001	<0.001
Barium	0.2	0.1	<0.1	0.1
Cadmium	<0.01	0.01	0.006	0.006
Chromium	0.01	<0.01	0.005	0.01
Copper	N/A	0.05	0.04	0.04
Lead	0.01	<0.01	0.006	<0.005
Mercury	<0.001	<0.001	<0.0005	<0.0005
Selenium	<0.001	<0.001	<0.001	<0.001
Silver	<0.01	<0.01	<0.01	0.01
Zinc	N/A	9.3	9.2	7.0
Fluoride	0.50	0.59	0.31	0.24
Nitrites	0.002	<0.01	N/A	N/A
Nitrates	4.2	0.71	2.1	1.03
Radium 226 (pCi/l)	<3.0	<3.0	0.3	0.0
Gross Alpha (pCi/l)	<1.5	1.0	3.5	0.3
Gross Beta (pCi/l)	16	14	10	0.9
Turbidity (NTU)	4.4	1.3	1.8	14
Total Coliform (#/ml)	<2.0	<1.0	<1.0	<1.0
Endrin (ug/l)	<0.02	<0.02	<0.01	<0.01
Lindane (ug/l)	<0.01	<0.02	<0.01	<0.01
Methoxychlor (ug/l)	<0.1	<0.1	<0.1	<0.1
2,4-D (ug/l)	<1.0	<1.0	<1.0	<1.0
2,4,5-TP Silvex (ug/l)	<1.0	<1.0	<1.0	<1.0
Toxaphene (ug/l)	<1.0	<1.0	<0.5	<0.5
Chlorides	8.0	6.0	7.0	24
Sodium	10	11	8.0	9.0
Phenols	<0.005	0.009	0.012	0.007
Maganese	0.54	0.29	0.37	0.4
Iron	2.3	0.22	0.56	0.71
Sulfates	1,150	1,110	1,330	964

* All values in milligrams/liter (mg/l) unless otherwise specified.
** Collection and analysis performed by Chester Engineers
*** Quadruplicate analysis
N/A = Not analyzed

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TABLE 4-5

GROUNDWATER MONITORING DATA
WELL 7

upgradient

Parameter*	Date Sampled** 11/18/81		02/24/82		09/09/82		11/17/82	
PARAMETERS TO INDICATE GROUNDWATER CONTAMINATION								
pH (units)***	7.7 7.7	7.7 7.7	7.5 7.5	7.6 7.6	7.5 7.5	7.5 7.5	7.46 7.48	7.55 7.56
Total Dissolved Solids***	560 568	540 560	572 556	584 564	588 604	600 584	616 612	620 616
Specific Conductance (umhos/cm)***	790 790	790 810	710 730	730 730	860 860	860 860	970 975	975 970
Total Organic Halogen***	0.046 0.030	0.029 0.021	0.014 0.013	0.020 <0.010	0.112 0.166	0.150 0.105	0.021 0.019	0.024 0.019
Total Organic Carbon***	3.0 5.0	3.0 5.0	32 33	31 32	58 59	60 57	2.0 1.0	1.0 3.0
OTHER PARAMETERS								
Arsenic	<0.001		<0.001		<0.001		<0.001	
Barium	0.2		0.1		0.1		0.1	
Cadmium	<0.01		<0.01		0.005		<0.005	
Chromium	<0.01		<0.01		0.018		<0.01	
Copper	N/A		0.03		0.63		0.02	
Lead	0.02		0.02		<0.005		0.006	
Mercury	<0.001		<0.001		<0.0005		<0.0005	
Selenium	<0.001		<0.001		<0.001		<0.001	
Silver	<0.01		<0.01		<0.01		<0.01	
Zinc	N/A		0.13		0.03		0.02	
Fluoride	0.52		0.50		0.63		0.47	
Nitrites	0.005		<0.01		N/A		N/A	
Nitrates	1.1		1.91		7.0		7.5	
Radium 226 (pCi/l)	<3.0		<3.0		0.5		0.7	
Gross Alpha (pCi/l)	0.8		1.7		0.2		0.4	
Gross Beta (pCi/l)	9.0		<1.0		0		0.3	
Turbidity (NTU)	4.8		1.2		2.0		12	
Total Coliform (#/ml)	<10		16		<1.0		<1.0	
Endrin (ug/l)	<0.02		<0.02		<0.01		<0.01	
Lindane (ug/l)	<0.01		<0.02		<0.01		<0.01	
Methoxychlor (ug/l)	<0.01		<0.01		<0.01		<0.01	
2,4-D (ug/l)	<1.0		<1.0		<1.0		<1.0	
2,4,5-TP Silvex (ug/l)	<1.0		<1.0		<1.0		<1.0	
Toxaphene (ug/l)	<1.0		<1.0		<0.5		<0.5	
Chlorides	20		15		21		24	
Sodium	34		35		55		57	
Phenols	<0.005		0.010		0.013		0.006	
Maganese	0.05		0.01		0.02		0.02	
Iron	0.84		0.18		0.10		0.06	
Sulfates	114		120		136		141	

* All values in milligrams/liter (mg/l) unless otherwise specified

** Collect...

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TABLE 4-6

GROUNDWATER MONITORING DATA

WELL 8 - Down

Parameter*	Date Sampled** 11/18/81	02/24/82	09/09/82	11/17/82
PARAMETERS TO INDICATE GROUNDWATER CONTAMINATION				
pH (units)***	7.7	7.4	7.5	7.60
Total Dissolved Solids***	372	308	379	396
Specific Conductance (umhos/cm)***	720	540	580	690
Total Organic Halogen***	<0.010	0.031	0.028	<0.010
Total Organic Carbon***	1.0	9.0	29	1.0
OTHER PARAMETERS				
Arsenic	<0.001	<0.001	<0.001	<0.001
Barium	0.1	<0.1	<0.1	0.1
Cadmium	<0.01	<0.01	<0.005	<0.005
Chromium	0.03	<0.01	<0.005	<0.01
Copper	N/A	0.02	0.01	0.01
Lead	<0.01	0.01	<0.005	<0.005
Mercury	<0.001	<0.001	0.0005	<0.005
Selenium	<0.001	<0.001	<0.001	<0.001
Silver	<0.01	<0.01	<0.01	<0.01
Zinc	N/A	0.37	0.02	0.02
Fluoride	0.51	0.25	0.25	0.06
Nitrites	0.006	<0.01	N/A	N/A
Nitrates	5.5	1.84	11.9	0.87
Radium 226 (pCi/l)	<3.0	<3.0	0.04	0.1
Gross Alpha (pCi/l)	1.9	<0.5	0.3	0.5
Gross Beta (pCi/l)	8.0	<1.0	0	3.8
Turbidity (NTU)	4.6	1.7	0.3	10
Total Coliform (#/ml)	70	<1.0	<1.0	52
Endrin (ug/l)	0.02	<0.02	<0.01	<0.01
Lindane (ug/l)	<0.01	<0.02	<0.01	<0.01
Methoxychlor (ug/l)	0.6	<0.1	<0.1	<0.1
2,4-D (ug/l)	<1.0	<1.0	<1.0	<1.0
2,4,5-TP Silvex (ug/l)	<1.0	<1.0	<1.0	<1.0
Toxaphene (ug/l)	<1.0	<1.0	<0.5	<0.5
Chlorides	22	10	20	21
Sodium	16	21	10	14
Phenols	<0.005	0.004	0.013	<0.004
Maganese	0.02	0.02	0.01	<10
Iron	0.13	0.08	0.02	0.02
Sulfates	68	80	42	68

* All values in milligrams/liter (mg/l) unless otherwise specified.
** Collection and analysis performed by Chester Engineers
*** Quadruplicate analysis
N/A = Not analyzed

TABLE 4-7

ANALYTICAL DATA - MONITORING WELL ANALYSIS
YEAR: TWO - QUARTER: ONE

DATE SAMPLED: March 9, 1983
REPORT DATE: March 25, 1983

Parameter	Chester Lab No: Units	Well 3 1225		Well 4 1226		Well 6 1227		Well 7 1228		Well 8 1229	
pH *	Standard Units	7.4	7.4	7.1	7.1	6.9	7.0	7.3	7.3	7.5	7.5
		7.4	7.4	7.1	7.1	7.0	7.0	7.3	7.3	7.5	7.5
Specific Conductance *	umhos/cm	2,400	2,400	1,280	1,290	2,000	2,010	935	930	690	710
		2,380	2,400	1,280	1,290	2,000	2,000	935	930	690	700
Total Organic Carbon *	mg/l	54	46	33	35	21	21	12	12	7	7
		48	53	32	32	21	21	13	11	7	7
Total Organic Halogens *	ug/l	62	54	40	36	34	32	25	23	17	16
		48	50	36	39	32	34	16	25	20	18
Total Dissolved Solids *	mg/l	1,932	1,944	956	960	1,792	1,796	624	616	448	436
		1,964	1,940	972	960	1,796	1,796	620	620	440	436
Lead		<0.005		<0.005		<0.005		<0.005		<0.005	

* Four replicate analyses per well
Source: Chester Laboratories

TABLE 4-8

ANALYTICAL DATA
MONITORING WELL ANALYSES

YEAR: TWO - QUARTER: TWO

DATE SAMPLED: August 4, 1983
REPORT DATE: November 4, 1983

Parameter / BCM Lab No.	Units	Well 3 8544	Well 4 8545	Well 6 8546	Well 7 8547	Well 8 8548
Chloride	mg/l	75.2	26.8	7.8	22.5	21.1
Iron	mg/l	7.57	0.20	0.31	0.20	<0.04
Manganese	mg/l	3.90	0.17	0.53	<0.02	<0.02
Phenols as Phenol	mg/l	0.046	0.01	0.005	<0.002	<0.002
Sodium	mg/l	509	53.3	8.76	49.1	10.1
Sulfate as SO_4	mg/l	1,280	234	1,150	131	37.2
pH *	Standard Units	7.1 7.2 7.2 7.2	6.9 6.9 6.9 6.9	6.8 6.9 6.9 6.9	7.2 7.2 7.2 7.2	7.3 7.4 7.4 7.4
Specific Conductance *, **	umhos/cm	4,880 4,890 4,870 4,860	1,510 1,530 1,530 1,540	2,460 2,470 2,500 2,450	996 996 1,010 996	635 658 664 658
Total Organic Carbon *	mg/l	464 448 439 434	131 136 135 133	83 85 86 86	61 59 61 59	33 31 33 31
Total Organic Halides *	ug/l	76 85 108 118	33 31 30 32	21 22 15 17	240 200 220 200	15 13 13 15
Total Dissolved Solids *, **	mg/l	4,049 4,094 4,177 4,080	1,039 1,072 1,038 1,048	2,267 2,290 2,318 2,302	641 608 655 628	388 404 435 431
Lead	mg/l	0.007	0.005	0.007	0.011	0.010
Alkalinity as $CaCo_3$						
Methyl orange	mg/l	1,600	513	293	307	200
Phenolphthalein	mg/l	<1	<1	<1	<1	<1
Bicarbonate	mg/l	1,600	513	293	307	200
Carbonate	mg/l	4.7	<1	<1	<1	<1
Hydroxide	mg/l	<1	<1	<1	<1	<1
Free Carbon Dioxide as $CaCO_3$	mg/l	101	81	47	24	20

* Four replicate analyses per well
** BCM Lab Nos. as follows: W3-3531, W4-3532, W6-3533, W7-3534, W8-3535
Source: BCM Eastern, Inc. - Laboratory Division

TABLE 4-9

ANALYTICAL DATA
MONITORING WELL ANALYSES

YEAR: TWO - QUARTER: THREE

DATE SAMPLED: September 29, 1983
REPORT DATE: December 6, 1983

Parameter	Well No: Units	Well 3 1754		Well 4 1755		Well 6 1756		Well 7 1757		Well 8 1758	
Chloride	mg/l	38		20.9		5.0		20.5		17.9	
Iron	mg/l	1.24		0.16		<0.04		9.26		<0.04	
Maganese	mg/l	2.95		0.23		0.25		0.19		<0.02	
Phenols as Phenol	mg/l	0.13		0.006		0.002		<0.002		<0.002	
Sodium	mg/l	203		39.0		6.43		38.4		8.27	
Sulfate as SO_4	mg/l	726		172		874		121		13.8	
pH	Standard Units	7.5	7.4	7.1	7.2	7.0	7.0	7.3	7.3	7.5	7.5
		7.4	7.4	7.2	7.2	7.0	7.0	7.3	7.4	7.5	7.5
Specific Conductance*	umhos/cm	3,640	3,630	1,320	1,370	2,260	2,300	1,020	1,030	649	659
		3,670	3,660	1,320	1,350	2,280	2,290	1,030	1,020	651	655
Total Organic Carbon*	mg/l	418	433	147	153	112	119	85	96	55	56
		422	443	148	166	117	119	87	96	56	58
Total Organic Halides*	ug/l	78	76	25	28	<10	<10	<10	<10	15	18
		77	77	27	30	<10	<10	<10	<10	18	17
Total Dissolved Solids*	mg/l	2,827	2,883	884	890	2,034	2,005	635	627	387	388
		2,871	2,843	879	878	2,022	2,047	649	646	386	394
Lead	mg/l	0.005		0.004		<0.002		0.103		0.002	
Alkalinity as $CaCO_3$											
Methyl Orange	mg/l	1530		620		347		313		206	
Phenolphthalein	mg/l	<1		<1		<1		<1		<1	
Bicarbonate	mg/l	1530		620		347		313		206	
Hydroxide	mg/l	<1		<1		<1		<1		<1	
Carbonate	mg/l	2		<1		<1		<1		<1	
Free Carbon Dioxide as $CaCO_3$	mg/l	243		196		139		50		21	

* Four replicate analyses per well
Source: BCM Eastern, Inc. - Laboratory Division

5.0 SUBSURFACE EXPLORATION AND SAMPLING

5.1 PARAMETERS SELECTED FOR ANALYSIS

Existing groundwater quality data for the Raymark landfill was reviewed prior to selection of parameters for the groundwater assessment and abatement program. Parameters selected by BCM and Raymark and approved by the PADER included:

Total dissolved solids	Sodium
Carbonate alkalinity	pH*
Sulfate	Lead
Chloride	

*Performed in the field

5.2 SUBSURFACE EXPLORATION PROGRAM

In order to assist in the better understanding of the hydrogeologic and hydrochemical conditions in the vicinity of the Raymark landfill, a subsurface exploration program was initiated by BCM as an element of the groundwater assessment and abatement program. Three groundwater monitoring wells were installed by W. Rollin Raab and Son of Hartsville, Pennsylvania, a state-licensed drilling contractor hired by BCM.

An additional upgradient monitoring well (Well 9) was installed in the Chickies Creek floodplain, approximately 700 feet northwest of monitoring wells 4 and 8. The purpose of this well was to allow the assessment of background groundwater quality in a hydrogeologic environment similar in character to conditions underlying Wells 4 and 8, but a greater distance removed from possible influence of the landfill.

A pair of monitoring wells (Wells 10A and 10B) were installed downgradient from the landfill, approximately 50 feet southwest of Well 3. Well 10A is an overburden well which is screened in the unconsolidated material (gravel and clay) overlying bedrock. Well 10B, located approximately 60 feet north of 10A, is a bedrock monitoring well with a solid steel casing established from the surface into solid bedrock and grouted in place.

A two-fold basis was used to select the location/construction of Wells 10A and 10B. The groundwater in these wells is representative of downgradient conditions. Wells 3 and 6, both of which show elevated sulfate concentrations, were drilled through the fill and cannot be considered to truly represent downgradient conditions. Wells 10A and 10B were positioned closer to the fill than ideal, but positioning them further away was physically impossible. The point for establishing one well in the overburden and one well in bedrock was to assess which hydrogeologic zones - floodplain alluvium, carbonate bedrock, both or neither - contained elevated concentrations of sulfate, total dissolved solids, and the other selected parameters.

5.3 SAMPLING PROGRAM

A comprehensive sampling program was included as a portion of the groundwater assessment and abatement program. Included were groundwater, storm sewer, surface water, and solid waste samples. All water sample locations were sampled twice during the course of the sampling program. Sampling locations are depicted on Figure 5. Water samples were obtained on October 13 and November 7, 1983. Solid waste samples were taken by Raymark personnel and delivered to BCM for analysis.

5.3.1 Groundwater Monitoring Wells

Samples were obtained from monitoring wells 9, 10A, and 10B. These samples were analyzed for the parameters listed in Section 5.1. The following protocol was used to obtain groundwater samples from monitoring wells:

1. The static water level in the well was measured using a calibrated electronic well probe. The measurement from the top of the casing to the top of the water was recorded. The well probe was rinsed with distilled water prior to use in each well.

2. The volume of standing water in the well was calculated by subtracting depth to water from total well depth and multiplying by the volume per foot of standing water.

3. A minimum of 3 to 5 times the standing volume of water in the well was evacuated. If the well went dry during pumping, the well was allowed to recover and then sampled.

4. A sample was obtained for chemical analysis from the well after evacuation was complete.

5. Wells 3, 4, 7, 8, and 10B were equipped with a permanently installed submersible pump. The samples were obtained directly from the pump discharge.

6. Samples from Wells 9 and 10A, which were not equipped with a submersible pump, were obtained as follows:

   a. A gasoline-operated suction pump was used to evacuate 3 to 5 volumes of standing water. The suction hose was rinsed with distilled water prior to insertion into the well.

   b. The water level was allowed to recover prior to sampling.

   c. A PVC bailer was used to obtain a groundwater sample from the well.

   d. The first two bail samples retrieved from the well were discarded.

7. Samples were field-filtered using a pressurized nitrogen gas Millipore filter with a 0.45-micron pore size.

8. Samples were placed in appropriately preserved and labeled, laboratory-prepared sample containers. Labeled containers were placed on ice and transported to BCM's laboratory in Norristown, Pennsylvania.

9. The PVC bailer and Millipore filtering device were cleaned between samples in the following sequence:

   a. Rinse with distilled, deionized (DI) water
   b. Wash with DI water and soap
   c. Rinse with DI water
   d. Wash with 50-50 solution of methanol and DI water
   e. Rinse with DI water
   f. Air dry prior to sampling

10. Chain-of-custody procedures were maintained for all samples.

5.3.2 <u>Plant Supply Wells</u>

To further assess the quality of groundwater beneath the plant site, three Raymark plant supply wells were sampled concurrently with the groundwater monitoring wells. Samples were obtained directly from taps at the well heads. The wells were run for a period of time sufficient to evacuate the system prior to obtaining a sample. The plant supply well samples were field-filtered, and a cleaning protocol was used identical to that used for monitoring well samples.

5.3.3 Storm Sewer

Water samples were obtained from the storm sewer which extends from Building 67 under the asphalt parking area to an outfall at Chickies Creek. These samples were used to assess the possible influence of the storm sewer on local groundwater or of the groundwater on water quality in the storm sewer. In addition, the possible effect of the storm sewer discharge on Chickies Creek was investigated. Grab samples were obtained from a catch basin adjacent to Building 67, from the outfall, and within Chickies Creek immediately downstream of the outfall. Storm sewer samples were field-filtered, and a cleaning protocol was used identical to that for monitoring well samples.

5.3.4 Chickies Creek

To evaluate the possible water quality impact of the landfill on the creek, water samples were obtained from Chickies Creek at three locations; upstream from possible landfill influence, near the confluence with the storm sewer discharge, and downstream of the landfill. The samples were field-filtered, and the established cleaning protocol was used between sampling locations.

5.3.5 Solid Waste

In addition to water samples, a series of solid waste samples were taken at the site. These samples, taken by Raymark personnel and delivered to BCM for analysis, included:

1. A composite sample of the coal pile
2. A composite sample of the contents of the dumpster buckets which are disposed of in the landfill
3. A sample from the older portion of the landfill
4. Four samples from the perimeter of the active landfill
5. A surface water sample from the active landfill

Leachates were generated from the solid samples using ASTM Method A (distilled water as the leaching medium). Leachates were analyzed for the following parameters:

Total dissolved solids	Chloride
Alkalinity series	Sodium
Hardness as $CaCO_3$	Lead
Sulfate as SO_4	Total Organic Carbon
pH	

The purpose of these samples was to evaluate waste streams, possible sources of contamination (coal pile), and the landfill itself in relation to local groundwater quality.

6.0 DISCUSSION OF ANALYTICAL DATA

Analytical data from the two water sampling events conducted during the assessment program are summarized in Table 6-1 and 6-2 (laboratory reports are contained in Appendix 4). These data form the basis for the following discussions of groundwater and surface water quality in the vicinity of the Raymark landfill. In addition, the results of analysis of leachates generated from waste streams, the coal pile, and the landfill are discussed in Section 6.4.

6.1 GROUNDWATER MONITORING AND PLANT SUPPLY WELLS

Groundwater quality in the area of the landfill and Raymark plant has been defined by several monitoring wells and the three plant water supply wells. Well 9 is upgradient and not influenced by the landfill. Well 4, located immediately adjacent to the currently active portions of the landfill, is somewhat impacted by the landfill. Wells 7 and 8 show little or no impact from the site, while Wells 3, 6, 10A, and 10B are immediately downgradient and show significant impact. This last group shows elevated levels of sulfate and bicarbonate. These are also the principal anion components which result in the high levels of total dissolved solids (TDS) found in these samples. These parameters are not harmful or toxic, but excessive levels lower water quality. Drinking water should not exceed 250 mg/l of sulfate or 500 mg/l of TDS.

High sulfate levels have a laxative effect on people not acclimated to it. High TDS indicates a brackish water that is not palatable. Sodium is not toxic, but it is a problem to certain people with heart disease.

The sodium level is nominally higher in Wells 10A and 10B than it is upgradient, but it is not significant in terms of water quality. Well 6 shows no increase in sodium, but Well 3 has levels that could be significant in certain cases. Hard water softened with zeolite softeners will have sodium levels similar to Well 3.

Traces of phenols were detected in the landfill monitoring wells. Water with detectable phenols is not suitable as a drinking supply, because it imparts an undesirable taste, especially after chlorination.

Analysis of the data collected during the groundwater assessment program indicates that the plant supply wells are not affected by the landfill.

Lead is of potential concern at the Raymark site, because it is a component of the material disposed of in the landfill. Traces of lead were found in samples from Wells 3, 4, 6, 7, and 8. Only one sample from

TABLE 6-1
SUPPLY WELL, MONITORING WELL, STORM SEWER AND CREEK WATER SAMPLES

First Round Samples
Date Sampled: 10/13/83

›arameter	BCM Lab No: Units	Plant Well 1 2795	Plant Well 2 2796	Plant Well 3 2797	Well 9 2798	Well 10A 2800	Well 10B 2799	Catch Basin 2802	Storm Sewer Outfall 2801	Storm Sewer & Chickies Creek Mix 2805	Chickies Creek at High St. Bridge 2803	Chickies Creek at Fruitville Pike Bridge 2804
'otal Dissolved Solids	mg/l	454	451	491	375	1,739	2,335	446	433	173	179	237
lkalinity as $CaCO_3$												
Phenolphthalein	mg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methyl Orange	mg/l	250	208	252	176	422	710	202	184	52	52	80
ılfate	mg/l	40.4	40.4	51.2	33.1	567.0	760.0	39.2	41.6	17.9	15.7	22.4
ıloride	mg/l	35.4	19.4	27.6	32.2	9.3	16.6	23.9	20.9	20.4	20.0	22.6
›dium	mg/l	16.9	10.1	18.1	12.0	29.8	63.5	12.4	11.3	9.6	10.2	10.7
›ad	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.017	0.075	<0.002	<0.002	<0.002
*	Standard Units	6.7	6.9	7.1	7.1	7.0	7.0	7.0	7.5	7.0	7.0	7.2
mperature *	°F	55	57	57	57	57	54	66	66	63	64	66

Field measurements
ırce: BCM Eastern, Inc.

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TABLE 6-2

SUPPLY WELL, MONITORING WELL, STORM SEWER AND CREEK WATER SAMPLES

Second Round Samples
Date Sampled: 11/7/83

Parameter	BCM Lab No: Units	Plant Well 1 4080	Plant Well 2 4081	Plant Well 3 4082	Well 9 4083	Well 10A 4084	Well 10B 4085	Catch Basin 4086	Storm Sewer Outfall 4087	Storm Sewer & Chickies Creek Mix 4088	Chickies Creek at High St. Bridge 4089	Chickies Creek at Fruitville Pike Bridge 4090
Total Dissolved Solids	mg/l	524	445	430	382	1,920	2,478	627	678	217	197	300
Alkalinity as $CaCO_3$												
Phenolphthalein	mg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Methyl Orange	mg/l	258	202	213	186	490	1060	212	212	66	58	94
Sulfate	mg/l	58.1	49.5	48.6	27.2	866.3	1,264.3	78.4	45.4	28.2	23.7	32.3
Chloride	mg/l	30.5	26.0	37.4	35.1	7.7	23.0	25.4	26.9	20.9	20.6	22.9
Sodium	mg/l	18.5	10.1	11.7	15.8	29.4	95.3	10.6	10.6	8.5	8.5	9.6
Lead	mg/l	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002
pH *	standard units	6.9	7.1	7.4	7.2	6.8	7.0	6.7	8.0	7.5	7.4	7.7
Temperature*	°F	55	54	54	55	57	56	59	58	44	42	43

* Field measurements
Source: BCM Eastern Inc.

Well 7 exceeded the drinking water limit of 0.05 mg/l. Data from the quarterly sample taken from Well 7 on September 29, 1983 indicated a concentration of lead of 0.103 mg/l, approximately twice the drinking water limit. However, this concentration is considered an anomaly, since data from previous quarterly samples taken in Well 7 were below the drinking water limit. In addition, preliminary data from the second year, fourth quarter (November 7, 1983) sample indicate a lead concentration of less than 0.002 mg/l. Lead was not detected in the plant supply wells or in Wells 9, 10A, and 10B.

6.2 STORM SEWER

A storm sewer originates in the plant, follows the southern side of the landfill, and discharges to Chickies Creek. Samples were collected at a catch basin near Building 67 and at the outfall at the Creek. Analysis of the first-round samples (October 13, 1983) indicated detectable levels of lead at the catch basin and at the outfall. A trace of lead (0.017 mg/l) was detected at the catch basin. The level at the outfall was 0.075 mg/l, slightly above the drinking water limit of 0.05 mg/l. Analysis of second-round samples (November 7, 1983) did not indicate detectable levels of lead above 0.002 mg/l for the catch basin or above 0.004 mg/l for the outfall.

It is possible that surface runoff may have conveyed some dust spilled while being transported to the landfill, which may have contributed to the slightly elevated lead levels detected in the first-round samples. Also, it is possible that groundwater infiltration from beneath the landfill may be entering the storm sewer, as the lead detected at the outfall was at a higher concentration than at the catch basin. However, since the lead levels detected in the groundwater at the site are generally at trace levels, infiltration is considered an unlikely source.

In all other parameters, the storm sewer flow had characteristics similar to the plant wells, indicating little or no impact from the landfill.

6.3 CHICKIES CREEK

Creek samples were collected in October and November 1983. Each set consisted of an upstream sample at the High Street Bridge, a sample of the stream water just below the storm sewer outlet, and a downstream sample at the Fruitville Pike Bridge. Based on these two rounds of samples, no measurable impact from the landfill or storm sewer was observed.

The upstream sample had a sulfate concentration of approximately 20 mg/l. The creek directly downstream of the landfill and storm sewer also contained a sulfate concentration of 20 mg/l. The downstream sample at

Fruitville Pike was marginally higher than the upstream samples at 23 mg/l. However, the Fruitville Pike sample was taken below the confluence of a northeastern branch of Chickies Creek with the main stem of the creek and may include sulfate contributions from other sources. In any case, the concentrations of sulfate measured in the creek are below the median concentration of 40 mg/l of sulfate reported for 53 wells and springs sampled in Lancaster County (Meisler and Becher 1971)*.

As mentioned in Section 3.2.3, pumping of the plant supply wells is currently causing localized discharge of stream water to the groundwater system from the reach of Chickies Creek adjacent to the Raymark plant site. As a consequence, groundwater containing elevated sulfates located immediately adjacent to the landfill is contained within the plant site.

An analysis was conducted of the possible affect of a shutdown of the plant supply wells. In this case, it is likely that groundwater contained beneath the landfill and plant site would begin discharging to the creek through seeps and springs. The effect of this groundwater discharge on creek water quality has been estimated.

Using the most conservative estimates, the net effect of the landfill on the stream would be a possible raising of the sulfate concentration in the stream water from current levels of 20 mg/l to approximately 50 mg/l. This is only slightly above the median level of 40 mg/l reported for 53 wells and springs in Lancaster County and is well below the drinking water standard of 250 mg/l for sulfate.

This estimate is based on the following assumptions:

1. Twenty inches per year of recharge to the groundwater system through the entire 12.6 acres of the plant site

2. A 10-year, 7-day low flow for the Chickies Creek at Manheim of 2 $feet^3/sec$

3. A sulfate concentration of 2,000 mg/l in the shallow groundwater beneath the site

All of these assumptions serve to overestimate the actual conditions which exist at the plant site. Therefore, the actual effect of the landfill on stream water quality should the production wells shut down would be a sulfate concentration in the stream of less than 50 mg/l.

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* Meisler, Harold and Becher, Albert 1971. Hydrogeology of the Carbonate Rocks of the Lancaster 15-Minute Quadrangle, Southeastern Pennsylvania. Groundwater Report W 26. Pennsylvania Department of Environmental Resources, Harrisburg, PA.

6.4 LEACHATES FROM SOLIDS SAMPLES

Following consultation with the PADER, it was agreed to include leachate analyses of solid waste and coal pile samples within the groundwater assessment program. The analyses were requested by the PADER in its comments on the proposed assessment program (see Appendix 1). Following discussions with Mr. Tom Miller, Hydrogeologist, PADER Bureau of Solid Waste Management, it was agreed to use ASTM Method A to generate leachates. This method uses distilled water for leaching, with no pH control. The samples are first dried; the quantity of water used for leachate generation is four times the amount of solid sample.

Test results from these samples are presented in Table 6-3 (laboratory reports of leachate analyses are contained in Appendix 5). The coal pile showed typical results, giving low pH, elevated TDS (including hardness and sulfate), and a trace of lead at 0.055 mg/l. Leachates from the dumpster composite and several landfill samples, as well as the ponded surface water, showed generally similar characteristics. The dumpster composite and surface water had no pH depression, while the east side landfill sample showed nominal pH depression. The other samples yielded an acid leachate. All leachates had high TDS, with the dumpster composite and closed landfill samples significantly lower than the others. Hardness, sulfate, and sodium levels were roughly proportional to the TDS levels. All of these samples showed detectable levels of lead.

The EP toxicity procedure, which is used to determine whether a solid waste is classified as a hazardous waste differs from ASTM Method A in that the EP procedure uses a 20:1 ratio of water to solids, and a pH of 5.2 is maintained during leachate generation. A lead concentration of 100 times the drinking water limit (5 mg/l) or greater in the leachate would allow the solid waste to be classified as hazardous. Although ASTM Method A uses less water and no pH control, those leachates produced from the Raymark waste samples which had a low pH (coal pile composite, closed portion of landfill; north, south, and west side of existing landfill) did not contain sufficient lead to be classified as hazardous. The closed portion sample has less leachable material than the active area. The waste in the dumpsters also was less leachable than the active area landfill samples.

Leachates generated from solid waste samples indicate that acid is released during the leaching process. Monitoring well data, however, show neutral pH values. This is because carbonate strata underlying the landfill provide a natural neutralization system. When acidic water contacts calcium carbonate, it dissolves in the form of calcium bicarbonate. In the case of sulfuric acid, calcium sulfate is formed along with the calcium bicarbonate, resulting in an increase in TDS.

TABLE 6-3

SOLID WASTE SAMPLES, LEACHATES OF SOLID WASTE SAMPLES AND SURFACE WATER SAMPLE

	BCM Lab No: Units	Composite Sample of Coal Pile 4128 4135 *	Composite Dumpster Buckets 4131 4138	Closed Portion of Landfill 4130 4137	North Side Existing Landfill 4132 4139	South Side Existing Landfill 4134 4141	East Side Existing Landfill 1433 4140	West Side Existing Landfill 4129 4136	Surface Water Existing Landfill 4142 **
Solids Total, %		92.6	24.1	82.2	46.3	52.6	37.7	48.6	---
Total Dissolved Solids	mg/l	197	538	200	3,630	693	2,190	667	3,580
Aklakinity as $CaCO_3$	mg/l								
Methyl Orange	mg/l	<4	200	<4	<4	<4	10	<4	330
Phenolphthalein	mg/l	<4	<4	<4	<4	<4	<4	<4	<1
Bicarbonate	mg/l	<4	200	<4	<4	<4	10	<4	328
Carbonate	mg/l	<4	<4	<4	<4	<4	<4	<4	1.5
Hydroxide	mg/l	<4	<4	<4	<4	<4	<4	<4	<1
Free Carbon Dioxide as $CaCO_3$	mg/l	<4	20	<4	<4	<4	39	<4	13.1
Hardness as $CaCO_3$	mg/l	20	196	32	1,820	340	1,050	200	1,200
Sulfate as SO_4	mg/l	15	100	14	2,420	380	1,240	28	1,556.7
Chloride	mg/l	<4	25	2.6	25	4	24	11	76.4
Sodium	mg/l	2.2	193	4.3	267	34	144	43	394
Lead	mg/l	0.06	0.26	0.018	0.83	0.91	1.92	0.96	2.90
Total Organic Carbon	mg/l	35	65	50	30	30	32	66	189
pH	Standard Units	3.0	6.9	2.7	3.2	3.6	5.4	2.9	7.7

* Samples with two lab numbers indicate data from solid sample and leachate prepared from solid sample (i.e., 4128 = coal pile solid sample, 4135 = leachate prepared from coal pile sample)

** Leachate not prepared from this sample.

Source: BCM Eastern, Inc.